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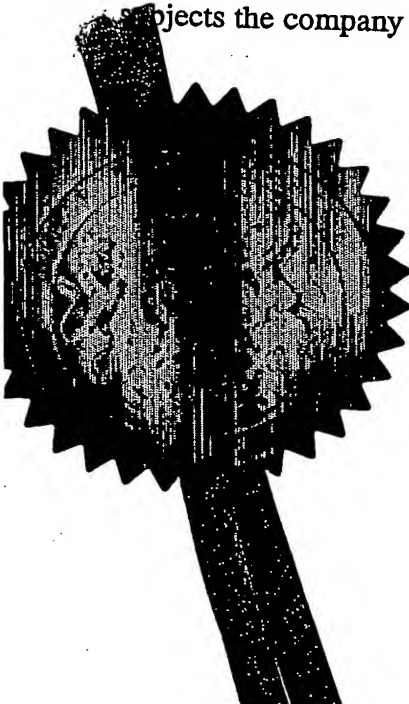
PCT

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23 SEP 2002

1. Your reference

HL77286/000/CIV

24SEP02 E750420-1 002847  
P01/7700 0.00-0222073.9

2. Patent application number

(The Patent Office will fill in this part)

0222073.9

3. Full name, address and postcode of the or of each applicant (underline all surnames)

TELEFONAKTIEBOLAGET L M ERICSSON (PUBL)  
SE-126 25 Stockholm  
Sweden

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

SE

64108075001

4. Title of the invention

TELECOMMUNICATIONS NETWORKS

5. Name of your agent (if you have one)

Haseltine Lake

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

Imperial House  
15-19 Kingsway  
London  
WC2B 6UD

Patents ADP number (if you know it)

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6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number  
(if you know it)Date of filing  
(day / month / year)

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing  
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8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

Yes

- a) any applicant named in part 3 is not an inventor, or
  - b) there is an inventor who is not named as an applicant, or
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Patents Form 1/77

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Continuation sheets of this form

Description 6

Claim(s) 2

Abstract 1

Drawing(s) 2 + 2

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Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77)

Request for preliminary examination and search (Patents Form 9/77)

Request for substantive examination (Patents Form 10/77)

Any other documents (please specify)

11. I/We request the grant of a patent on the basis of this application.

Signature

*Mr C I Vigars*

Date

23/9/02

12. Name and daytime telephone number of person to contact in the United Kingdom

Mr C I Vigars

[0117] 910 3200

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TELECOMMUNICATIONS NETWORKS

The present invention relates to  
telecommunications networks, and in particular to third  
5 generation mobile telephone networks and systems.

BACKGROUND OF THE INVENTION

In third generation mobile telephony systems,  
power control is important to obtain desirably high  
10 capacity and efficiency, particularly in CDMA systems.  
The variable that is controlled is called quality.  
Quality of the communication is controlled with  
reference to one of two quality measurements: BER (Bit  
Error Rate) or FER (Frame Erasure Rate). Usually an  
15 integrating controller is provided to achieve a steady  
state of performance with zero control error. The  
control scheme used is cascade control, see for example  
Figure 1 of the accompanying drawings. The idea with  
cascade control is to make an inner control loop (2)  
20 much faster than an outer control loop (4). For  
transmission power control (TPC) the inner loop  
controls signal to interference ratio (SIR). The outer  
loop sets the SIR reference value  $SIR_r$  for the inner  
loop. The goal of the outer loop is to control the SIR  
25 reference to achieve a BER that is equal to the BER  
reference  $BER_r$ . To get a control system that in steady  
state achieves a BER that is equal to the BER  
reference, an integrating controller (9) can be used.  
The cascade controller illustrated in Figure 1  
30 comprises an inner control loop (2) and an outer  
control loop (4). Both control loops have an input of  
a received signal  $(y(k))$ . The outer control loop 4  
serves to estimate the BER (5) for comparison with a  
BER reference signal. A subtracter (7) calculates the  
35 difference between the reference signal and the BER

estimate to supply an input signal to an integrating controller (9). The integrating controller (9) produces a SIR reference signal.

5 The SIR reference signal is compared with an SIR estimate from an SIR estimation unit (3) in the inner control loop (2). The difference between the SIR reference and the SIR estimate is supplied to a step controller (11) for determining the transmission power of the output signal  $u(k)$ .

10 A known problem with an integrating controller is that it becomes unstable if the control signal saturates. This problem is often referred to as the windup problem. TPC saturation of the control signal corresponds to situations when the maximum transmitter power is used.

15 The problem with windup in the power control algorithms for third generation mobile telephony systems is well known. However no solutions to the problem have yet been presented. The specific problem of which protection is WCDMA makes several additions to anti-windup schemes used in other areas necessary.

20 As is well known, integrating controllers have the nice property of being able to achieve zero control error in steady state. As an example of an integrating controller, a continuous time PI-controller is shown in Figure 2, which illustrates a continuous time controller. Discrete time controllers have similar behaviour. For example, Karl Johan Åström and Tore Hägglund. PID Controllers: Theory, Design and Tuning. Instrument Society of America, Research Triangle Park, NC, second edition, 1995.

25 A known problem with integrating controllers is that the integrator part turns unstable when the control signal saturates. This instability occurs because feedback from the process is needed to

35

stabilize the controller, which is not open loop stable. In the case of transmission power control, saturation can occur when maximum transmission power is used. In this situation the transmission power can only be decreased, which can be seen as open loop operation of the integrator.

As the controller is not open loop stable the controller state (the integrator, I-part) can start to build up a large state. This usually results in that it takes a long time for the control loop to start functioning again after the saturation state is left. This problem is usually referred to as the windup problem.

#### SUMMARY OF THE PRESENT INVENTION

An embodiment of the present invention can provide a method for controlling a radio frequency (RF) transmitter, the method comprising:

using an integrating controller to produce a required signal-to-interference ratio (SIR) signal from a desired error signal;

producing an estimated SIR signal to the integrating controller as a feedback signal, thereby stabilising the required signal-to-interference ratio (SIR).

It is emphasised that the term "comprises" or "comprising" is used in this specification to specify the presence of stated features, integers, steps or components, but does not preclude the addition of one or more further features, integers, steps or components, or groups thereof.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a controller for a third generation mobile system;

Figure 2 illustrates an integrating controller;  
and

Figures 3 to 5 illustrate respective controllers  
embodying the present invention.

5

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

To explain the invention, a simplified model for  
the controlled process is derived, and is illustrated  
in Figure 3. The SIR control loop is modelled as a  
saturation (21) and a delay (23).

The process that maps SIR to BER (BLER) is  
modelled as a static function (25). This is not  
important for the invention and can be modelled by any  
suitable means. A problem is that SIR and BER (BLER)  
cannot be directly measured. SIR and BER (BLER) can  
only be estimated. This is indicated in Figure 3 with  
two estimation noises  $W_R$ .

When transmission power saturates (i.e. when the  
maximum transmission power is reduced) SIR will no  
longer follow  $SIR_r$  (SIR reference). In the tracking  
approach of the present invention the difference  
between SIR and  $SIR_r$  is calculated and fed back to  
stabilize the integrating controller. If  $v_K$  is small  
the difference will be small, except when the  
transmission power is saturated. The tracking solution  
is shown in Figure 4. The PI-controller with tracking  
signal input to the integrator is shown in Figure 5.  
As before, a continuous time loop is shown, but a  
discrete time version is simply derived and would have  
similar behaviour. Embodiments of the present  
invention are applicable to transmission power control  
systems in both the up-link and the down-link.

Figure 4 is a schematic illustration of a tracking  
solution embodying the present invention. The  
components of Figure 3 are shown, namely the saturation

21, delay 23 and the static mapping function 25. A required SIR ( $SIR_r$ ) is input to this model to produce an SIR estimate (SIR est) and a BER estimate (BER est).

5 The tracking solution is illustrated by elements 31, 33, 35, 37, 39 and 41. A required BER ( $BER_r$ ) is supplied via a log function 31 to an adder 33. Also supplied the adder 33 is the BER estimate, via a log function 41, so that the adder 33 produces an error result equal to the difference between the required BER and the estimated BER. The log functions are  
10 introduced to ensure that the control loop behaves in a linier fashion. A controller 35 (CBER) receives as one input the error signal E. The controller also receive a tracking signal PS. The controller produces a signal  
15 representing the required SIR for supply to the SIR control loop model. The required SIR signal is also supplied, via a delay element 37, to an adder 39 which produces the tracking signal by subtracting the required SIR signal from the estimated SIR signal.

20 Figure 5 illustrates the controller 35 in more detail. As can be seen, the controller includes a gain element 43 of gain K which receives an input e as supplies an output  $eK$  to an adder 44. The error signal e is also supplied to a component 45 having a transfer function  $K/T_i$  (where  $T_i$  is the integration time) for  
25 supplying to another adder 46. A second input of the adder 46 is provided by the output from a second component 49 having a transfer function  $1/T_t$  (where  $T_t$  is the tracking time) as supplied with the error signal  
30 ES. The output of the adder 46 is integrated by the integrator 47 ( $1/s$ ) and supplied to the adder 44. The output of the adder 44 gives the required SIR signal. It can be seen that the controller 35 provides the following transfer function as given in equation 1.

35



$$SIR_r = eK + \frac{1}{s} \left( \frac{eK}{T_i} + \frac{e_s}{T_i} \right)$$

5 An alternative implementation would be to use the estimated tracking signal  $e_s$  to do "conditional integration". In such an implementation the integrator part is not updated if  $e_s$  is larger than a threshold, i.e. if  $|e_s| > e_{threshold}$  the integrator is not updated. This solution also prevents the integrator state to build up a large value in scenarios of power  
10 saturation.

The best practice implementation of the tracking arrangement includes to do some filtering of  $e_s$  and a dead zone. This makes the impact of estimation errors smaller in cases of not saturating power.

15 The invention is a new application of the tracking approach to the windup problem. To the knowledge of the inventor, tracking has not before been used to tackle the problem of saturation in transmission power control. The major improvement compared to existing  
20 approaches are that the saturation is estimated by comparing  $SIR_r$  and  $SIR_{est}$ . Without this feature it would not be possible to generate a tracking signal. The invention is applicable to transmission power control systems in both the up-link and the down-link.

CLAIMS

1. A method for controlling a radio frequency (RF) transmitter, the method comprising:  
5 using an integrating controller to produce a required signal-to-interference ratio (SIR) signal from a desired error signal;

producing an estimated SIR signal relating to an actual SIR of the RF transmitter; and

10 supplying the estimated SIR signal to the integrating controller as a feedback signal, thereby stabilising the required signal-to-interference ratio ( $SIR_r$ ).

2. A radio frequency transmitter controller comprising:

15 an integrating controller operable to produce a desired signal-to-interference ratio (SIR) signal from an input error signal; and

20 an estimation unit, connected to receive a sampled output signal, and operable to produce an estimated SIR signal relating to a sampled output signal,

25 wherein the estimation unit is operable to supply the estimated SIR signal to the integrating controller, and the integrating controller is operable to produce the desired SIR signal from the input error signal and the estimated SIR signal.

3. A controller as claimed in claim 2, wherein the integrating controller has the transfer function:

30

$$SIR_r = eK + \frac{1}{s} \left( \frac{eK}{T_i} + \frac{e_s}{T_e} \right)$$

35 in which  $SIR_r$  is the desired SIR signal,  $e$  is the input error signal,  $K$  is a constant,  $e_s$  is the estimated SIR signal and  $T_i$  and  $T_e$  are time constants relating to

the integration and estimation unit respectively.

4. A controller as claimed in claim 2 or 3,  
wherein the desired SIR signal is set to produce a  
5 desired bit error rate (BER) at the output of the  
transmitter.

ABSTRACT

Telecommunications Networks

5 A RF transmitter in a telecommunications network is controlled using an integrating controller. An estimated SIR signal is used as a feedback signal for the integrating controller.

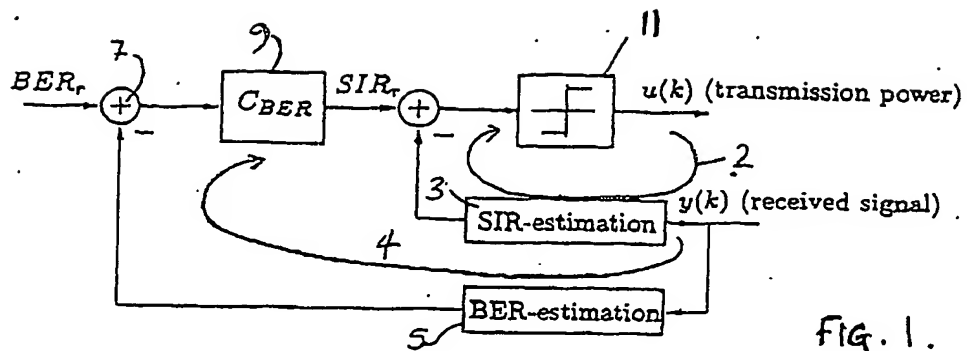


FIG. 1.

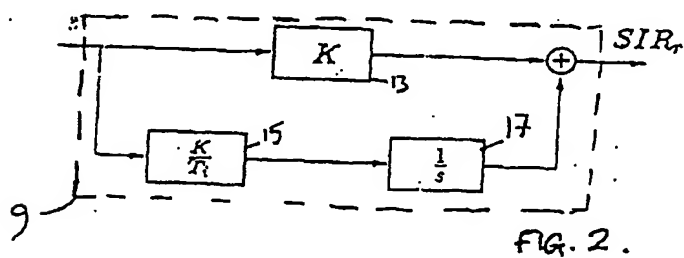


FIG. 2.

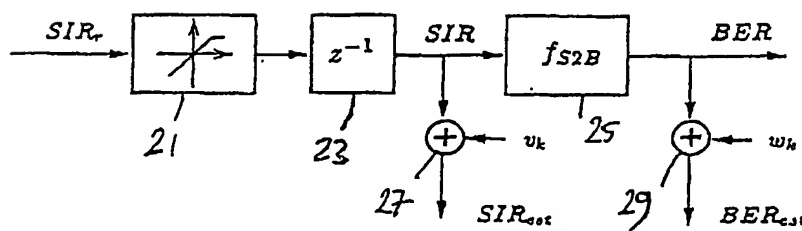
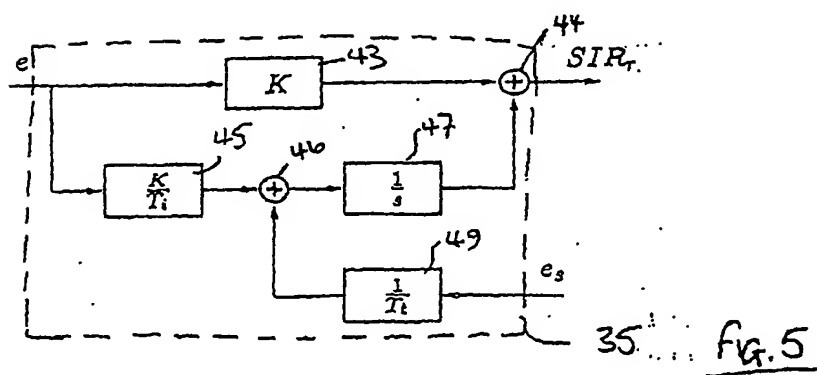
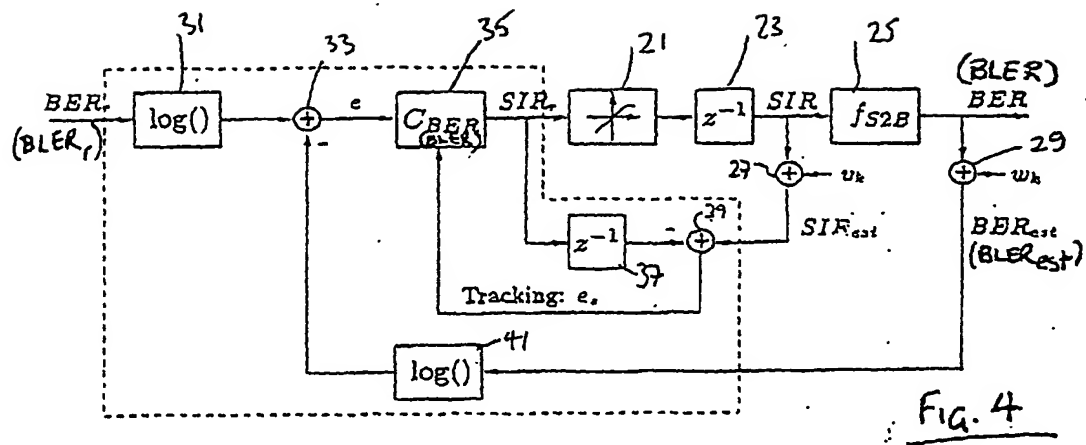


FIG. 3.

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